STATUS OF MINERAL RESOURCE INFORMATION FOR THE TAOS AND PICURIS INDIAN RESERVATIONS, TAOS COUNTY, NEW MEXICO

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Administrative Report BIA 79
1981

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SUMMARY AND CONCLUSIONS

The Taos and Picuris reservations appear to be devoid of mineral occurrences, except for sand and gravel deposits on both reservations and copper mineralization in the northwest corner of the Picuris Reservation. A wide variety of minerals has been prospected and mined in areas near the reservations, always on a small scale and seldom, if ever, on a profitable basis. Some of these prospects are briefly described in this report.

Within a radius of 30 miles of Taos, mineral production having an annual value in excess of $32,000,000 is currently being obtained, primarily from molybdenum and perlite and small amounts from ground mica and sand and gravel.

Only sand and gravel is now being produced commercially on the Taos Reservation from one mine at a rate of about 30,000 cubic yards annually other deposits on both reservations are worked sporadically.

Small amounts of placer gold have been mined in the past from the Rio Grande and from other streams on or bordering reservation lands. No gold is presently being produced.

On the Picuris Reservation, an extensive mineralized zone containing secondary copper minerals and some gold has been exposed to a limited extent, but no ore has been produced.

Some indications exist that the reservation lands may contain geothermal resources. Studies to date do not indicate the extent or quality.

It is possible that the apparent scarcity of mineral occurrences on reservation lands is attributable to lack of prospecting. It is also remotely possible that mineral deposits still might be found on unexplored reservation lands. The failure to find economic mineral deposits in immediately adjacent areas, despite intensive prospecting there, however, suggests that investigation of reservation lands can be given only low priority.

INTRODUCTION

This report was prepared for the Bureau of Indian Affairs (BIA) by the U.S. Geological Survey (USGS) and the Bureau of Mines (USBM) under an agreement to compile and summarize available information on the geology, mineral resources, and potential for economic development of certain Indian lands. Source material included published and unpublished reports and personal communications. No fieldwork was performed.

In this report, the Indian lands are called "Indian Reservations" for simplicity, although such lands may in fact be one or more of several types, including patented land grants, purchased land, allotted land, ceded forest land, or other.

Both the Taos and Picuris Indian Reservations lie entirely within Taos County, New Mexico. Taos Indian Reservation consists of 95,341 acres (BIA-1978) in three separate parcels of land (see Figure 1). Two triangular parcels of land are on the relatively level alluvial surface of the Taos plateau between the Rio Grande Gorge on the west and the Sangre de Cristo Mountains on the east. The third parcel of land is roughly rectangular and extends eastward from the Taos plateau to the Colfax County line.

One triangular parcel of land of about 17,000 acres extends north and south along the eastern side of the Rio Grande for about 10 miles; the base

of the triangle extends northeastward along the Rio Pueblo de Taos for about 6-½ miles from its junction with the Rio Grande; the easternmost corner of the triangle is about 3 miles due west of the town of Taos.

The second triangular parcel of land of about 3,000 acres is between U.S. Highway 64 and the Rio Hondo and is bisected by State Highway 3. The southern point of the triangle is nearly 4 miles northwest of the town of Taos; one leg of the triangle extends north-northwest about 4-½ miles, the other leg extends west-southwest about 2-¼ miles south of, and more or less paralleling, the course of the Rio Hondo.

The rectangular parcel of land lies mostly north and east of the town of Taos and includes that town and the settlement of Taos Pueblo within its boundary. The maximum dimensions are about 15 miles east-west and 10-¼ miles north-south, and it contains 75,341 acres.

The two triangular parcels of land and the westernmost part of the rectangular parcel are on the piedmont terrace or bajada terrace that extends from the base of the Sangre de Cristo mountains to the Rio Grande canyon, a distance of about 10 miles. The terrace surface slopes southwestward to the Rio Grande at a gradient ranging from about 50 to 150 feet per mile.

The eastern five-sixths of the rectangular parcel is in the rugged terrain of the Sangre de Cristo Mountains. Reservation lands on the piedmont terrace lie mostly at elevations between 6,800 and 7,600 feet. In the rough eastern lands, the valley bottoms are nearly all above 8,000 feet, and many of the peaks and ridges exceed 11,000 feet. The lowest point on the reservation is about 6,050 feet at the junction of the Rio Grande and the Rio Pueblo de Taos. The highest point is 13,113 feet at Old Mike Peak near the eastern end on the northern boundary of the large rectangular parcel of land.

In the vicinity of Taos, about 2,820 acres (BIA office files) of reservation land are non-Indian owned. The original land grant for Taos Pueblo amounted to 17,390 acres. The additional lands now owned by the Pueblo have been purchased by the tribe or transferred from National Forest land. Some boundaries are still being adjusted, and the acreages given herein are approximations only.

The Picuris Indian Reservation is square, a little over 5 miles on each side, with a total area of about 14,947 acres (BIA-1978). It is about 11-½ miles south-southeast of Taos, at the junction of Rio Pueblo and Rio Santa Barbara with Embudo Creek. The highest point in the reservation is 9,840 feet on a ridge near the eastern end of the northern border; the lowest point is 7,100 feet where Embudo Creek leaves the western boundary. Three valley bottoms comprise the only relatively level land on the reservation and all but about 15 percent is non-Indian owned; these lands lie mostly at elevations between 7,200 and 7,700 feet and slope downstream at a rate of about 150 feet per mile. All the rest of the reservation is hilly to mountainous terrain.

U.S. Highway 64 and State Highways 3 and 68 all intersect at or near Taos. The major highways and secondary roads give ready access to all of the relatively flat portions of the Taos Indian Reservation. The mountainous area is accessible only by foot or horseback. State Highway 75 crosses the Picuris Indian Reservation from east to west

connecting with State Highway 68 to the west and State Highway 3 to the east 3 miles. State Highway 76 connects with Highway 75 from the south within the reservation.

A small runway near Taos and another on the Picuris reservation can handle small, light aircraft. Larger commuter aircraft service is available at Santa Fe, about 55 miles southeast of Taos, and Albuquerque, 60 miles southeast of Santa Fe, is serviced by several major airlines.

The Denver Rio Grande and Western Railroad once had a station at Embudo, 11 miles west of the Picuris Reservation and 25 miles east southeast of Taos, but the line was abandoned many years ago. The nearest railstop is now at Lamy about 80 miles south of Taos (U.S. Department of Commerce, 1974).

The climate is generally cool and semiarid, the temperature averaging about 26° Fahrenheit in the coldest months to 69° in the hottest months, although extremes as low as -27° and as high as 101° have been recorded. Annual precipitation at Taos averages about 12 to 13 inches, the wettest months being in the summer and the driest in the winter. The mountainous areas are cooler and wetter than the lower areas. Snow falls over the entire area in wintertime, lasting only a short time in the lowlands, but often staying on the higher mountains until August.

The mountainous areas of the Taos Indian Reservation are drained by the westward- and southward-flowing Rio Lucero and its tributaries and by the westward-flowing Rio Pueblo de Taos and its tributaries. In the vicinity of Taos, the streams combine and flow southwestward as the Rio Pueblo de Taos through the lower Pueblo Canyon to the Rio Grande. The two tracts of Taos Reservation land located on the piedmont terrace also drain into the Rio Pueblo de Taos and partly through a less deeply entrenched drainage system directly into the Rio Grande.

The Picuris Indian Reservation is drained by three streams and their tributaries, the Rio Pueblo, the Rio Santa Barbara, and Chamizal Creek. They all join Embudo Creek, which flows westward to the Rio Grande.

Agriculture, tourism, and employment in the surrounding communities are the principal sources of income for both reservations. Picuris produces a unique variety of pottery, which is prized locally for cooking ware as well as for sale to tourists (Kingsolver, E. J., BIA, 1979, oral communication). Limited amounts of sand and gravel are mined on both reservations, especially on the Taos Reservation.

Significant to this study is the apparent opposition of the Pueblo Indians in general and Taos Pueblo specifically to any activity or development that would alter or modify the social, cultural, religious or environmental aspects of their way of life (letter and enclosures, Florence H. Ellis to Jim Hecker in U.S. Department of Energy, 1980).

PREVIOUS INVESTIGATIONS

No specific investigations of the geology and mineral resources of the Taos and Picuris Indian Reservations have been made. Studies on a regional scale, or of adjacent regions, include all or parts of the reservations. Studies of neighboring mineral deposits suggest features that might be applied by projection or inference to the reserva-

tion lands. The geology of both reservations is shown on Dane and Bachman's (1965) geologic map of New Mexico. Picuris Reservation geology is covered by Miller and others (1963) and by Montgomery (1953). Geology of part of the northern Taos Reservation is covered by Clark and Read (1972). Lambert (1966), Baltz and Bachman (1956), Kelley (1956), Baldwin (1956), Woodward and Ingersoll (1979), Muehlberger (1979), Condie (1979), Nielsen and Scott (1979), Barrett and Kirschner (1979), and other authors have presented studies that either cover or are related to the geology of the reservation in guidebooks of conferences of the New Mexico Geological Society. Mineral deposits in the vicinity of the reservations have been reported by Silliman (1880), Lindgren and others (1910), Lasky and Wooton (1933), Schilling (1960), Jahns and Ewing (1976), and others.

PHYSIOGRAPHY

The Taos Reservation is situated in the Taos Plateau part of the Rio Grande depression and in the Taos Range and Tres Ritos Hills of the Sangre de Cristo Mountains. The western boundary is along the deeply incised Rio Grande Gorge which is entrenched 600 feet below the Taos Plateau. The Plateau slopes gently to the southwest, rising about 6,500 feet in elevation near the gorge to about 8,100 feet at the base of the south-trending western front of the Taos Range, which rises abruptly over 2,000 feet to a rugged mountainous area of deep canyons and high peaks above timberline. The glaciated peaks along the northern boundary of the reservation are 12,000 to 13,000 feet in elevation; and peaks on the dissected rolling upland of the Tres Ritos Hills along the southern boundary are 9,500 to 10,500 feet in elevation. The larger streams are incised 2,000 feet or more into the uplands.

The Picuris Reservation is bisected by the broad flat Rio Pueblo Valley. The northern half of the reservation rises sharply 1,800 feet or more into a maze of ridges and deep canyons on the flanks of the Picuris Range, an isolated southwestward projecting spur of the Sangre de Cristo Mountains. The southern half of the reservation rises gently southeastward on the highly dissected Penasco Plateau and in the Penasco Valley.

GEOLOGY

General

The Taos and Picuris Indian Reservations are in northwestern New Mexico, largely in the Sangre de Cristo Mountain range. The Embudo fault, Picuris-Pecos fault, large isoclinal folds and several smaller faults and folds control the structure of the Precambrian. The oldest Precambrian metavolcanic and metasedimentary rocks are intruded by granites of Precambrian age; these are overlain locally by thin Mississippian units and by the Pennsylvanian Madera Formation (Figure 2). Locally overlying the Madera Formation are the Tertiary Picuris Tuff and Quaternary sands and gravels.

Stratigraphy

Precambrian Rocks

The metavolcanic and metasedimentary Precambrian units of the Taos and Picuris reservations, though discussed separately, may be correlative units and the Embudo granite, in the Picuris area, may be related to the granite within the Taos reservation.

Taos Reservation

Paragneiss and Quartzite

The paragneiss unit is gray to buff, composed of quartz, feldspar, and mica, well banded. It is commonly interbedded with quartzite, amphibolite and a small bed of quartz-mica schist.

The quartzites are typically fine to medium grained and white to buff in color. Foliation is generally subparallel to bedding, with gradational to sharp contacts with the paragneiss, and frequently interfingering with it.

Metavolcanic rocks

The felsic volcanic rocks are fine-grained and buff to brown in color. Bedding and primary structures are well preserved throughout the rocks. Well-shaped phenocrysts of plagioclase, quartz, and volcanic rock fragments suggest that the rocks are tuffs and related volcaniclastic deposits.

The amphibolite is black to dark green, massive to foliated, and may be banded on a scale of millimeters to centimeters. Near granitic contacts the amphibolite may be brecciated and migmatitic; it generally occurs as thick or thin units concordant with the metavolcanic and metasedimentary units. Sills in felsic volcanic rocks probably represent basalt that underwent in situ fractional crystallization.

Granites

The granites range from pink to orange and from medium to coarse grained. Some are folded and deformed, representing late, syntectonic plutons. Others, seen as small dikes, are not foliated and distinctly discordant, representing post-tectonic intrusions.

Pegmatites and Quartz Veins

Both pegmatites and quartz veins are minor but widespread. Composition is chiefly potash-feldspar, quartz and muscovite.

Picuris Reservation

Ortega Formation

The Ortega Formation is composed of three members, in ascending order: Lower Quartzite, Rinconada Schist and Pilar Phyllite. The Lower Quartzite, 2,500 feet thick, is coarse-grained, glassy appearing, gray to gray-white and massive. Distinctive thin beds of sillimanite-kyanite exist throughout the Member. The Rinconada Schist, 1,800 feet thick, is composed of four distinct units:

an andalusite-biotite hornfels, 200-300 feet thick; staurolite schist and gneiss, 200-500 feet thick; quartzite, 200-600 feet thick; and muscovite-quartz-biotite-garnet phyllite, 200-400 feet thick; associated with these are hornblende granulite (calcareous granulite, hornblende-garnet hornfels, microcline gneiss, bytownite granulite, and black hornfels. The Pilar Phyllite Member, 2,300 feet minimum thickness, is a distinctive horizon-marker of dense, homogeneous, gray-black to black phyllite, commonly containing many quartz veins that vary in thickness, from large veins which follow joints to narrow veins parallel to cleavage.

Vadito Formation

The Vadito Formation is composed of two members, a conglomerate member consisting of quartzite interbedded with felsites, meta-dacites, meta-andesites and amphibolites, and a schist member interbedded with amphibolites. The quartz conglomerate is 2,000 feet thick; its matrix is fine-grained, gray-white micaceous quartzite. Pebbles and cobbles are coarse-grained quartzite, gray-white to gray, and may show dark banding which is not parallel to micaceous foliation of the quartzite. The interlayered felsites, near the base of the formation, are dense, gray-white, white or flesh-pink and white in color. Some are gneissic because of parallel orientation of biotite. Metavolcanic rocks of this member are gray, dark gray, greenish-gray and gray-black rocks. Hornblende is an essential constituent. The schist member, 2,500 feet thick, consists of a quartz-muscovite schist and phyllite and a quartz-biotite granulite. The quartz-biotite granulite is a fine-grained, sandy, crudely foliated rock. Minor metasedimentary rocks occur within this member and are similar to the andalusite-biotite hornfels of the Rinconada Schist Member of the Ortega. The associated amphibole is fine-grained, porphyritic, and shows traces of irregular cavities; inclusions of quartzite containing garnet and amphibole are also scattered throughout the member.

Embudo Granite

The types of rocks included within the Embudo Granite are leucogranite, gneissic granite, and a biotite granite, which is coarse-grained, with milky-white plagioclase intergrown with flesh-pink microcline. Evenly distributed biotite forms a crude foliation and xenoliths are present throughout most of the outcrops. A gneissic granite may be present within the reservation; it is coarsely granitoid with a gray-white to pinkish-white groundmass which parallels streaky patches of brownish-black or grayish mica imparting the crude gneissic foliation. A leucogranite, whitish to flesh-pink, also appears within the unit.

Other Rock Types

Pegmatites, genetically related to the Embudo Granite, vary greatly in size, from thread like veinlets a few inches long to large dikes several feet thick and hundreds of feet long. Although not in the reservations, the nearby Harding Pegmatite is the best known and was once a major source of non-metallic minerals. In general, the pegmatites are of a coarse-grained granitic type with micro-

cline and quartz making up 90 percent of most masses. Aplites are fine-grained, flesh-pink to gray-white with an average thickness of only a few inches.

Quartz veins vary from tiny veinlets to massive veins tens of feet wide, concordant or discordant, and may be pre-metamorphic, metamorphic, syntectonic or post-tectonic in age. Many pegmatites grade into, or are cut by, veins of quartz.

Diabase dikes, 50-75 feet thick, are coarse-grained, dark olive green to brownish-black when fresh, reddish-brown when weathered. Dikes have a nearly vertical attitude and closely-spaced, blocky joints that are frequently filled by calcite.

Pennsylvanian Rocks

The oldest sedimentary rocks in the region occur as local small erosional remnants of Mississippian limestone and sandstone which are here included with the Pennsylvanian rocks. The southeastern half of the Taos Reservation is covered by rocks of Pennsylvanian age, with the Sandia Formation at the base, overlain by Madera Formation and Sangre de Cristo Formation, the uppermost part of which may be Lower Permian in age. These rocks are all shown on Figure 2 as the Madera Formation.

The Sandia Formation consists of thick beds of conglomeratic sandstone, siltstone, carbonaceous shale, and some thin limestones. The Madera Formation contains two distinct units, a lower gray limestone with interbedded shale, siltstone and thin sandstone, and an upper arkosic member of coarse-grained conglomeratic sandstone, fossiliferous gray limestone, gray shale, and thin red and purple shale. The Sangre de Cristo Formation intertongues with the Madera and is composed of conglomerate, arkosic sandstone, red, green, and gray shale and siltstone and rare thin limestones.

Tertiary Rocks

Tertiary volcanic, intrusive, and clastic sedimentary rocks are widespread in the region. Relationships of the various units to each other are complex and generally poorly understood, but the units are locally divided into mappable units which may be correlated and dated only approximately.

Picuris Tuff

The Picuris Tuff, 1,250-1,750 feet thick, consists of a basal conglomerate of coarse fragments primarily of Precambrian sillimanite-bearing quartzite, overlain by brick-red, yellow, olive-green or white clay. The clay is overlain by boulder beds with tuffaceous matrix, white volcanic ash, thin beds of shale and compact marl, and thin, highly altered basalt flows.

Santa Fe Formation

The Santa Fe Formation conformably overlies and interfingers with the Picuris tuff beds. It is a pale pink to buff colored, extremely fine sandy or clayey unit, with minor thin layers of gravel, the pebbles of which may be of volcanic material.

Servilleta Formation

The Servilleta Formation is a widespread sequence (though a minor unit within the Picuris reservation) of vuggy flows of olivine tholeiite. Within the basalt are clasts of quartzite and phyllite derived from the surrounding mountain ranges. Abundant layers of micaceous sand and limonite occur throughout the formation and a sandy gravel facies caps much of it.

Quaternary Deposits

Terrace Gravels

A deposit of partly consolidated gravel occurs at the western edge of the Picuris Reservation, and at several other localities in the region, resting largely on Precambrian rocks at varying elevations above current drainage levels. The relative age and correlation of the gravel are unknown.

Alluvium

Alluvium is widespread in most valleys throughout the region, ranging from boulders and gravel in the steeper mountain valleys to sand and silt with gravel lenses in most larger valleys to fine sand silt and clay in some areas of the broad valleys on the Taos Plateau. A few of the larger areas of alluvium are shown on Figure 2. Some of the gravel cover on the Servilleta Formation, especially some alluvial fans near the mountain fronts, may also be Quaternary alluvium but it is not shown separately on Figure 2.

Structure

Taos Reservation

High-angle faults separate the down-faulted Rio Grande Depression from the uplifted Sangre de Cristo Mountains. These frontal faults trend south along the Taos Range, then turn southwest along the Picuris Range. Other high-angle faults are widespread; many have south trends, but a second group trends east to northeast. Most show predominantly dip-slip movement, but others are tear faults with strike-slip movements. There is a large thrust-detachment fault block located within the reservation, where Pennsylvanian rocks lie over younger rocks. Folds and folding, though important in the Picuris reservation, are minimal in the Taos.

Picuris Reservation

Medium to high grade metamorphic formations cross the Picuris reservation with an east-northeasterly trend in the southern region and a northeastward trend in the northern region; they generally dip steeply toward the south-east. Several isoclinal folds delineated in the region to the west of the reservation may extend into the reservation. The north-trending Picuris-Pecos fault, east of Picuris Peak, separates the east-west Precambrian structures of the Picuris block from the north-south trending Laramide structures of the area to the east, which is transitional into the structures in the Sangre de Cristo Mountains. Right-lateral slip (probably Precambrian) caused major horizontal displacement of beds.

MINERAL RESOURCES

General

The Taos and Picuris Indian Reservations are in a heavily mineralized region containing a wide variety of useful elements and minerals. Within a radius of 30 miles of Taos there are numerous mines and prospects or occurrences of gold, silver, copper, lead, zinc, molybdenum, tungsten, bismuth, perlite and pegmatite minerals. Despite considerable exploration and development, few of these mines and prospects, with two notable exceptions, have been productive or profitable for any appreciable length of time. Anderson (1957) estimated that the total value of gold, silver, copper, and lead produced in Taos County prior to 1923 was less than $100,000. There has been no appreciable production of these materials since then. Successful mining in the region has been confined to molybdenum, gold, perlite, and sand and gravel.

Except for sand and gravel and one copper prospect on the Picuris Indian Reservation, no mineral deposits have been reported on the reservation lands. Whether this is attributable to lack of exploration or to lack of deposits is unknown.

Metallic Mineral Deposits

Small-scale placer mining and prospecting by the Spanish was probably the only metal mining in the region prior to the discovery of the Elizabeth town gold placers and lode gold deposits in Colfax county about 25 miles northeast of Taos in 1866 (Schilling, 1960). Because these mines were profitable (Lindgren, 1910), a mining boom ensued that led to intensive prospecting of the surrounding region for gold and silver as well as other metals. It also led to the establishment of the Baldy (Ute Creek), Cimarroncito, Elizabeth town (Moreno) and Ponil mining districts in Colfax County, and the Anchor (LaBelle), Picuris (Copper Hill), Red River, Rio Grande Valley, Twining (Rio Hondo) and Glenwoody mining districts in Taos County (Lindgren, 1910; Lasky and Wooton, 1933; Anderson, 1957; and Schilling, 1960).

A considerable amount of mining and milling activity has been carried on, such as: mills and smelters were built, shafts were sunk, and tunnels were driven (Lindgren, 1910). Only the deposits of the Elizabethtown district seem to have been substantially profitable until about 1922 when production of molybdenite from the Questa Molybdenum mine, about 13 miles north of the Taos Reservation, assumed significant proportions. It became by far the most important mine in the region.

The only other important metal mine in the region is the Harding Pegmatite deposit, about 2 miles west of the Picuris Indian Reservation. It has produced important quantities of tantalum, niobium, beryllium, and lithium ores, as well as associated nonmetallic minerals.

Gold Placers

Carruth (1910) quotes statements by Cecil A. Deane of Denver, Colo., describing evidence that the Spanish explorers conducted extensive placer mining along the Rio Grande and its tributaries in the vicinity of Taos, during the period between

1640 and 1690. They make mention of an alleged shipment of $2,000,000 in gold dust made from the area prior to 1680. Schilling (1960) more conservatively concedes that the Spaniards probably did do some small scale mining in the area, as does Lindgren (1910). Benjamin Silliman (1880) of Yale University examined the Rio Grande placer deposits and enthusiastically endorsed them, particularly the section between the Red River on the north and Embudo Creek on the south. In this same section, Carruth (1910) states that auriferous gravels are found in the Red, San Cristobal, Hondo, Taos, and Embudo rivers. The last three of these rivers are either nearby or drain reservation lands, whereas the Rio Grande forms the western boundary for 10 miles and the Rio Taos the southern boundary for 6-½ miles of portions of the Taos Indian Reservation. Silliman (1880) describes auriferous gravels overlying, underlying, and intercalated with basalt along the lands bordering the Rio Grande. This presumably could include the portions of the Taos Indian Reservation lying on the alluvial plateau. Other writers report the presence and small-scale recovery of placer gold in the Rio Grande, its tributaries, and the alluvium from the Sangre de Cristo Mountains, but are skeptical of its potential value (Lindgren, 1910; Lasky and Wooton, 1933; Anderson, 1957; Schilling, 1960).

In the early 1930's, a dredge was constructed to work the Rio Grande channel just below its junction with the Rio Taos near the southwest corner of a part of the Taos Indian Reservation. The operation was carried on for several weeks but was abandoned because of inability to handle the large size and quantity of basalt boulders in the gravel (Anderson, 1957; Schilling, 1960).

Lode Gold

Numerous lode gold occurrences were prospected and mined, after the 1866 discovery of the rich Elizabethtown placers, about 18 miles northeast of the Taos Reservation (Lindgren, 1910; Lasky and Wooton, 1933; Anderson, 1957; Schilling, 1960; Clark and Read, 1972). These appear to be basically quartz veins in monzonite, rhyolite, or andesite with auriferous sulfides, mostly pyrite. Some also contain chalcopyrite, galena, sphalerite and other sulfide minerals. Some of the gold has been freed by oxidation and the ore was treated in arrastres, stamp mills, and Huntington mills. Some small smelters were also constructed.

Few of the mines produced ore for very long, some for only a few days. Except for a few mines near Baldy Mountain, about 10 miles northeast of the Taos Reservation, the gold production was very small. Mines near the reservation lands include:

Klondike Mine

The Klondike mine is about 3 miles east of the Taos Reservation and 1-¼ miles southeast of the Pay Ore mine. Hundreds of feet of workings explore pyrite-bearing, copper-stained, quartz veinlets in sandstone. A mill was erected, reportedly for gold, but there are no records of production (Clark and Read, 1972).

Denver-Climax Mine

The Denver-Climax mine is about 4 miles northwest of the Taos Reservation. Drifts explore

a rhyolite dike and an auriferous quartz vein. Production is not recorded (Clark and Read, 1972).

Glenwoody Prospect

Lindgren (1910) mentions this gold deposit on the Rio Grande, about 5 miles west of the Picuris Indian Reservation. The gold ore, in a wide band of quartzite in Precambrian schist, was supposed to contain $1.40 to $3.00 per ton and to be amenable to cyanide treatment. A mill and powerplant were built, but failed to recover more than $0.40 per ton.

Despite the great number of gold-bearing veins apparently present in the Taos mountains, none appear to have been profitable.

Copper

Copper, like gold, is found in the region around the reservations. Occurrences have been described by Lindgren (1910), Lasky and Wooton (1933), Anderson (1957), Schilling (1960), Clark and Read (1972), and others. Usually the copper is in the same quartz veins as the gold previously mentioned. It is one of the mineral assemblage, along with pyrite, galena, sphalerite, and other sulfides with which gold is mostly closely associated. A few mines were explored primarily for copper.

Pay Ore Mine

The Pay Ore mine is about 2 miles east-northeast of the Taos Reservation and 1-¼ miles northeast of the Klondike gold mine. Several hundred feet of drifts explore copper mineralization on a fracture in arkose and shale. There is no record of production (Clark and Read, 1972).

Frazier Copper Mine

The Frazier Copper mine is at Twining about 14 miles northeast of Taos or 3-½ miles north of the Taos Indian Reservation. The mine, opened in 1900, was equipped with a mill and smelter. Operations in 1904 produced some ore, but apparently were not satisfactory and were not continued. In 1942 and again in 1956 interest was revived. A leaching plant erected in 1956 was soon abandoned. Pods and stringers of quartz and calcite, with grains and veinlets of chalcopyrite, pyrite, bornite, and films of malachite, azurite, and chrysocolla, occur along shears and fractures in a 200-foot-wide shear zone striking N. 65° E. and dipping 80° N., in Precambrian talc schist and amphibolite (Schilling, 1960).

Highline Copper Prospect

The Highline Copper prospect is on Bull of the Woods Mountain about 3-½ miles north of the Taos Reservation and apparently on the same shear zone as the Frazier mine. Here, it strikes N. 70° E. and dips 70°-80° N. A 6- to 10-foot wide section in the shear zone, containing 1- to 6-inch-wide veins of iron- and copper-stained quartz with rare azurite, cuprite, and chalcocite, has been exposed in 2 bulldozer cuts and some shallow workings. There has been no production. About 2 miles northeast of the Highline, old workings known as the "Comstock Copper Prospect" explore the same shear zone showing quartz stringers with chalcopy-

rite, specular hematite, malachite, azurite, and chrysocolla. There has been no production. There are also other copper showings in this vicinity.

Champion (Copper Hill) Copper Mine

The Champion (Copper Hill) Copper mine is between secs. 1 and 20, T. 23 N., R. 11 E., about 2 miles west of the Picuris reservation (Schilling, 1960). Exploration began in 1900 with driving 350 feet of adit, sinking two shafts 180 feet and 60 feet, and constructing a 100-ton-per-day mill that soon burned. Eventually another 25-ton gravity mill was built, and in 1916 to 1918 small shipments of concentrate and direct smelting ore were made. The operation was not satisfactory and closed in 1920. In 1955 some copper-bearing silica was shipped as flux to the El Paso smelter. The deposit consists of north-south trending copper-gold-silver veins dipping 50° W. to vertical in Precambrian metaquartzite. Mineralization is glassy quartz, pyrite, chalcocite, cuprite, malachite, chrysocolla and limonite, argentite, and tetrahedrite. Gold is often present.

Wilson Mine

At the Wilson mine which is about ½ mile east of the Champion mine, shallow workings were used to explore another similar vein (Lindgren, 1910; Schilling, 1960).

McClure, Anderson, and Emerald Lodes

In the northwestern corner of the Picuris reservation are three mining claims, McClure Lode, Anderson Lode and Emerald Lode. These claims were patented to non-Indian claimants in 1909, on lands already patented as the Picuris Pueblo in 1864. As of December 1979, it appears that this problem of duplication of patents has been resolved in favor of the Picuris Indians (BIA office files). Lindgren (1910) describes what are probably these claims as follows:

> About 4 miles northeast of the Copper Hill and Wilson mines oxidized copper ores with hornsilver, similar to those of the Copper Hill mine, were encountered. Chalcopyrite, gold and silver have been reported 1-½ miles west of the Wilson mine. These localities were not visited by the writer.

In the office files of the BIA Northern Pueblos Agency, in Santa Fe, is an inter-office memorandum by Duval Corporation dated 3 July 1972; referring to the three claims, it states "these are located in the northwest part of the Pueblo Grant and contain substantial showings of copper oxide mineralization." Specimens of copper stained quartz and quartz-mica schist gathered by BIA personnel from the waste dumps of shallow workings in the area appear to contain malachite, chalcocite, and cuprite. An assay of a bag of this material shows: 1.86 percent copper and 0.081 ounce of gold per ton (BIA Office files).

Lead-Zinc

As in the case of copper, lead and zinc as galena and sphalerite are found among the aurifer-

ous sulfides in many of the gold-quartz veins. A few of the deposits appear to be of interest primarily for the lead and zinc. Among these are (Lindgren, 1910; Schilling, 1960):

Silver Star Prospect

The Silver Star Prospect is about 4 miles north of the Taos Reservation and has three narrow galena-bearing quartz veins exposed in a 15-foot (shear?) zone, striking N. 85° W. and dipping 20° N. The galena is argentiferous and assayed 18 ounces of silver per ton. Six tons of ore were produced (Schilling, 1960).

Jack Pot Prospect

The Jack Pot Prospect is about 4 miles north of the Taos Reservation and was prospected in the 1890's. A fault zone between Precambrian amphibolite and Tertiary granite, striking N. 50° W. and dipping 70° SW, contains stringers and pods of quartz up to 4 feet thick and 50 feet long. The quartz has disseminations and streaks of specularite, chalcopyrite, sphalerite, and galena. There was probably little or no production. There are other similar occurrences of galena and sphalerite in this vicinity.

Lindgren (1910) noted the presence of a narrow quartz vein containing pyrite, chalcopyrite, sphalerite, and molybdenite at the mouth of Rio Hondo canyon about 1-½ miles north of Taos Reservation.

Tungsten

A tungsten (Wichita?) mine, located in sec. 16, T. 23 N., R. 11 E., about one mile northeast of the Wilson mine mentioned under copper deposits, is less than 1 mile west of the Picuris Reservation. Actual production is not known (Dale and McKinney, 1959), but the mine is supposed to have produced ore during World War I and some 6 tons in 1955 (Schilling, 1960). A shaft 175 feet deep and an opencut were used to explore small, malachite-stained quartz veins cutting Ortega quartzite. The veins strike S. 20° E. and dip 65° to 70° west. "The ore consists of quartzite and vein quartz with malachite, wolframite, and fibrous, satiny brown tourmaline. The wolframite occurs as small elongated crystals in the vein quartz, and the malachite as a coating on fracture faces" (Dale and McKinney, 1959). This is the only mine reported to have produced tungsten. Schilling (1960) believes that further study might be worthwhile.

Bismuth

About 2 miles northwest of the northwest corner of the Picuris Reservation, a small prospect is said to have produced a small amount of secondary bismuth minerals about 1950. The bismuth occurs as bluish secondary oxide minerals along quartz veins in Precambrian Ortega metaquartzite (Schilling, 1960). Jahns and Ewing (1976) list bismuth and bismuthinite as minor accessory minerals in the Harding Pegmatite about 5 miles southwest of this prospect. Miller, Montgomery, and Sutherland (1963) also mention bismuth in the Harding mine.

Beryllium, Lithium, and Tantalum

Any discussion of beryllium, lithium, niobium, and tantalum essentially is limited to one deposit, although pegmatites scattered throughout the region contain accessory amounts of minerals composed of these elements and others. Only one deposit, that at the Harding mine, has had them in sufficient quantity to constitute mineable ore.

Harding Mine

The Harding mine is in sec. 29, T. 23 N., R. 11 E., about 2 miles west of the Picuris Reservation. The deposit was known to prospectors prior to 1900, but was first recognized as a potential source of lithium minerals in 1918. Mining for lithium was carried on from 1919 to 1930, when the mine closed. From 1942 to 1947, the mine was reopened to produce the tantalum mineral microlite. From 1950 to 1958, it was operated primarily for the production of beryl. The mine since has been leased to the University of New Mexico for preservation as one of the State's unusual natural assets. Unmined reserves of tantalum ore are still in place (Jahns and Ewing, 1976).

The mine has been described by many writers, including Just (1937), Soule (1946), Berliner (1949), Montgomery (1953), Anderson (1957), Schilling (1960), Jahns and Ewing (1976), and many others. The mine consists of a group of pinching and swelling pegmatite dikes, 20 to 50 feet thick, that crop out in a zone about 2,500 feet long and 150 to 500 feet wide. They strike west to west-northwest and dip southward at low angles. The dikes are granitic, composed of quartz, potash, feldspar, albite, and muscovite with lesser amounts of apatite, beryl, garnet, magnetite, microlite, and tantalite-columbite. Country rock is hornblende-plagioclase schist and quartz muscovite schist. Productive dikes show well defined zoning whereas the more homogenous dikes are relatively barren of economic minerals. Mining has been small scale, highly selective, and mostly by open pit, although some underground work has been done. Table 1 shows the production according to Jahns and Ewing (1976).

TABLE 1
Harding Mine Production

Period	Mineral	Grade	Quantity	Unit
1919-1930	Lepidolite	Ground and high-grade ore		
		3% Li_20	13,500	tons
1942-1947	Microlite	68% Ta_20_5		
		7% Nb_20_5	22,116	pound
	Spodumene	7% ? Li_20	41	tons
	Lepidolite	3% Li_20	558	tons
	Tantalite-columbite	43% Ta_20_5	500	pound
	Beryl	11% Be0	23	tons
1950-1958	Beryl	11.2% Be0	690	tons
	Beryl	5.5% Be0	184	tons

Figured at prices prevailing at the time the minerals were mined, the gross value of production would be on the order of $630,000. Spread over an active period of 24 years and considering mining, milling, and transportation costs, it does not appear to have been a very profitable venture.

Nonmetallic Mineral Deposits

Sand and Gravel

Sand and gravel is found over most of the lowland areas of the Taos Reservation, and over considerable portions of the Picuris Reservation. Pits have been mined on both reservations for local use as required, and one commercial operator holds a lease on the Taos Reservation. The lease site, exceeding 6 acres, is located in the northern tip of the larger of the two triangular areas of reservation land just north of U. S. Highway 64, and about ½ mile east of the Rio Grande gorge. Since 1970, the lease has been held by Taos Gravel Products, which pays a per-yard royalty on the gravel produced. In 1975, the lease was amended to provide for an annual increase in the royalty rate, and in 1978 the lease was renewed for 5 years, increasing the lease acreage from the original 3 acres to 6.3 acres . From 1978 to 1983, the royalty increases from $0.31 to $0.35 per cubic yard in $0.01 annual increments (BIA Office files). Table 2 shows the production.

TABLE 2
Recorded Gravel Production

Period	Cubic Yards
1 Jun 70 to 31 May 71	5,141
1 Jun 71 to 31 May 72	14,534
1 Jun 72 to 31 May 73	12,120
1 Jun 73 to 31 May 74	18,931
1 Jun 74 to 31 May 75	16,623
1 Jan 75 to 29 Sep 75	
partial duplication ?	11,005
1 Oct 75 to 30 Dec 75	2,100
1 Jan 76 to 30 Apr 76	10,179
1 May 76 to 30 Jun 76	2,641
Jul, Aug Sep (no production?)	
Oct 76 to Jun 77	11,400
Aug 77	4,449
Sep 77 to Aug 78	39,411
1 Sep 78 to 31 Aug 79	31,699
Sep 79	3,584
Total recorded production	183,817

Note: Figures are from files of the BIA Northern Pueblos Agency

This gravel lease is the only commercial mining operation at present on either of the reservations. It probably satisfies the local demand for gravel.

Mica

Considerable prospecting and mining for mica has taken place in Taos and Rio Arriba Counties in the general vicinity of the two reservations (Holmes, 1899; Just, 1937; Jahns, 1946, and others). More than 100 deposits are known to exist and some of them have been mined for sheet mica from the 17th century up to the present. Most, if not all, of the significant production has come from the Petaca district about 25 miles west of Taos. Only one mine is now producing ground mica.

The mica occurs in pegmatite dikes, which are found throughout the region. Commercial mica might be found on reservation lands. Ground mica also might be produced from mica schists found in the study area.

Sillimanite-Kyanite

Schilling (1960) states "Kyanite and sillimanite are abundant in a few thin layers in the lower quartzite member of the Precambrian Ortega Formation. A layer of muscovite schist several feet thick, containing as much as 25 percent of coarse bladed kyanite and some grains of ilmenite, can be traced for several miles along its strike south of Copper Mountain. This description places the deposit just west of the Picuris Reservation and suggests that the deposit probably extends into it.

He describes another area about 3 miles north of the Picuris Reservation in which "Two quartz-muscovite schist or gneiss layers contain radiating clusters of pink sillimanite needles, blue blades of kyanite, and some ilmenite, magnetite, and hematite. The two layers are 3 to 25 feet thick (average thickness, 10 feet), crop out about 1,000 feet apart, and can be traced for over a mile. The northern layer is especially rich, containing as much as 50 percent of the two minerals; the Hondo Canyon sillimanite--kyanite prospect is in this bed (N. ½ sec. 25, T. 24, R. 11 E.)." Sillimanite-kyanite bearing beds have been found in the northeast portion of the Taos Reservation (Clark and Read, 1972).

Clay

White to pale buff golden-flecked (mica) pottery, said to have superior qualities as cooking ware, is made at Picuris Pueblo from clay obtained from a site about 2 miles east of the Picuris Pueblo (Kingsolver, E. J., BIA, oral communication). Schilling (1960) and Montgomery (1953) describe a somewhat similar material in a deposit called Cueva Blanca White Cave) mine about 7 miles north of the Picuris site. Schilling says this is pyrophyllite, kaolin, and muscovite mica formed from hydrothermally altered, pulverized, sillimanite-kyanite muscovite gneiss. Such material, J:rom at least one place, evidently forms a superior ceramic material. Both of these occurrences appear to be on or near the Picuris-Pecos fault, as shown by Miller, Montgomery and Sutherland (1963).

Stone

Large amounts of granite and basalt are present on the reservations and probably could be used for crushed rock and dimension stone if a need arose. No such production is known to have taken place. Some thin-bedded limestone near Tres Ritos, about 9 miles east-southeast of the Picuris Reservation, has been mined for building stone.

Energy Resources

Coal

Prospects along the Rio Fernando de Taos, about 2 miles south of Taos Pueblo, explored carbonaceous material in the Pennsylvanian Sandia Formation. No coal of commercial grade or thickness has been found (Schilling, 1960).

Geothermal Resources

Summers (1976) describes four hot springs in the general vicinity of the study area. The Taos Reservation lies within the boundary of Known Geothermal Resource Field No. l, defined by the State Land Office as "lands that may be capable of-producing geothermal resources in commercial quantities" (Summers, 1979). It is possible that additional studies now in press will result in the Picuris Reservation also being included in that category (Kay Hatton, Staff Geologist, State Energy and Minerals Department, oral communication). At present there is insufficient information to form any opinion of the geothermal characteris-

tics of the reservations, but indications suggest that both may have geothermal potential.

MAP COVERAGE

The U.S. Geological Survey has published topographic maps on standard 7-½-minute quadrangle sheets at a scale of 1:24,000 (Figure 3). Maps of this scale giving complete coverage of the reservations are:

Picuris Indian Reservation
Penasco
Trampas

Taos Indian Reservation
Arroyo Hondo
Arroyo Seco
Eagle Nest
Los Cordovas
Palo Flechado Pass
Pueblo Peak
Taos
Taos S. W.
Wheeler Peak

The U. S. Geological Survey Army Map Series 1:250,000-scale map sheet Raton (NJ 13-11) covers both reservations, as does the U.S. Geological Survey 1:500,000-scale Geologic Map of New Mexico. These are all available from:

U.S. Geological Survey, Distribution Branch, Central Region, Box 25286, Denver Federal Center, Denver, Colorado, 80225

Geology of Picuris Indian Reservation, on a scale of 1:63.360, is published as plate 1 in Memoir 11 (Miller, Montgomery and Sutherland, 1963), and the geology of the extreme northeastern corner of the Taos Indian Reservation, on a scale of 1:48,000, appears as Plate 1 in New Mexico Bureau of Mines Bulletin 94 (Clark and Read, 1972). These publications are available from the:

New Mexico Bureau of Mines and Mineral Resources, Workman Center, Campus Station
Socorro, New Mexico 87801

Aerial photographs of the area can be obtained from the EROS Data Center, U.S. Geological Survey, Sioux Falls, South Dakota, 57198.

RECOMMENDATIONS

There is reason to believe that the Indians do not wish to have their lands investigated. If that attitude is confirmed, no further work should be scheduled.

If the Indians request it, the following actions may be considered.

1. Geologic mapping of both reservations, emphasizing evidences of mineralization.
2. Stream sediment sampling of both reservations to locate possible anomalous areas.
3. Examination of the known copper-bearing zone on the Picuris Reservation to determine whether or not exploration is merited.

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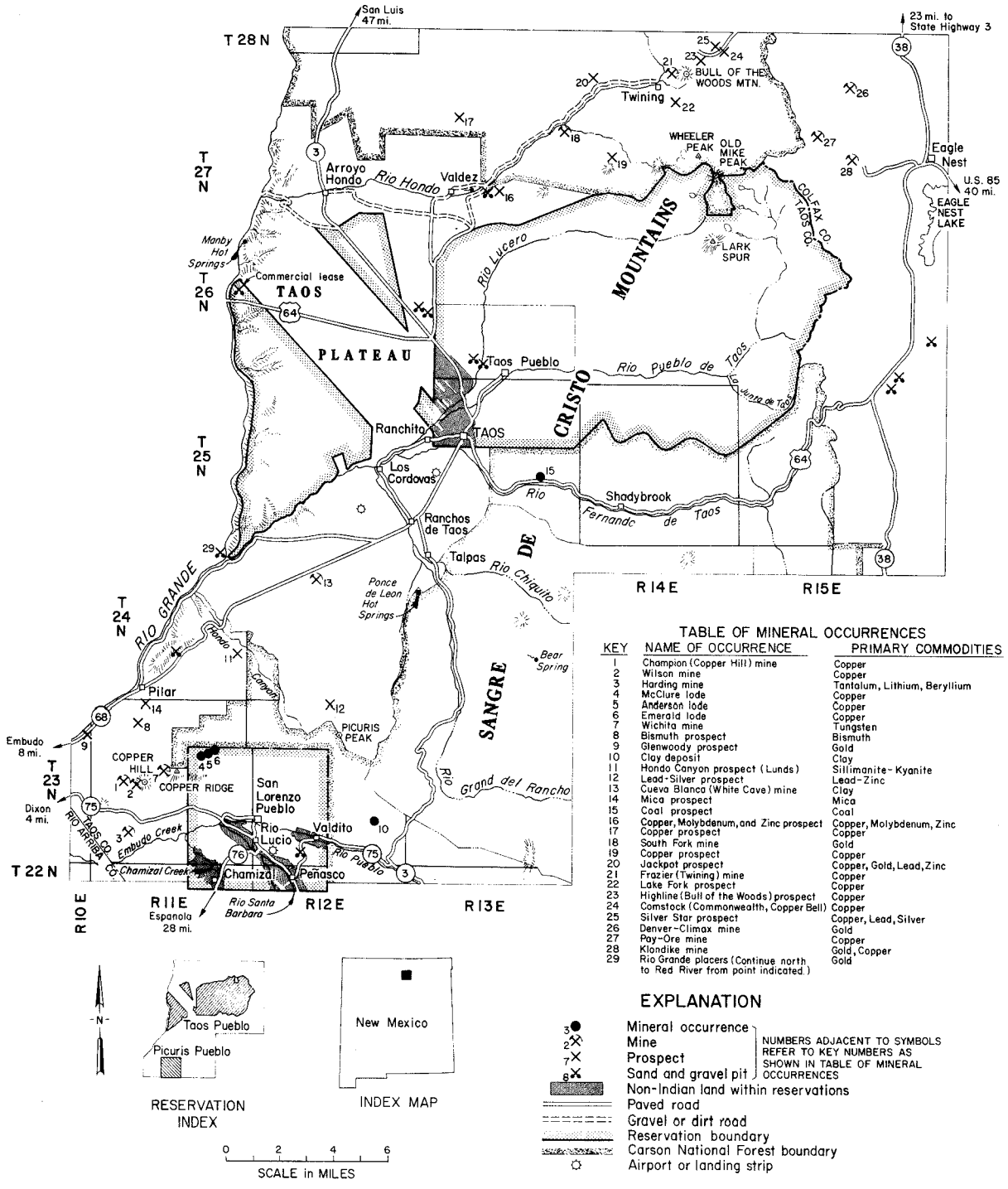

Figure 1. Location map showing some mineral occurrences in the general area of the Taos and Picuris Indian Reservations, TaosCounty, New Mexico.

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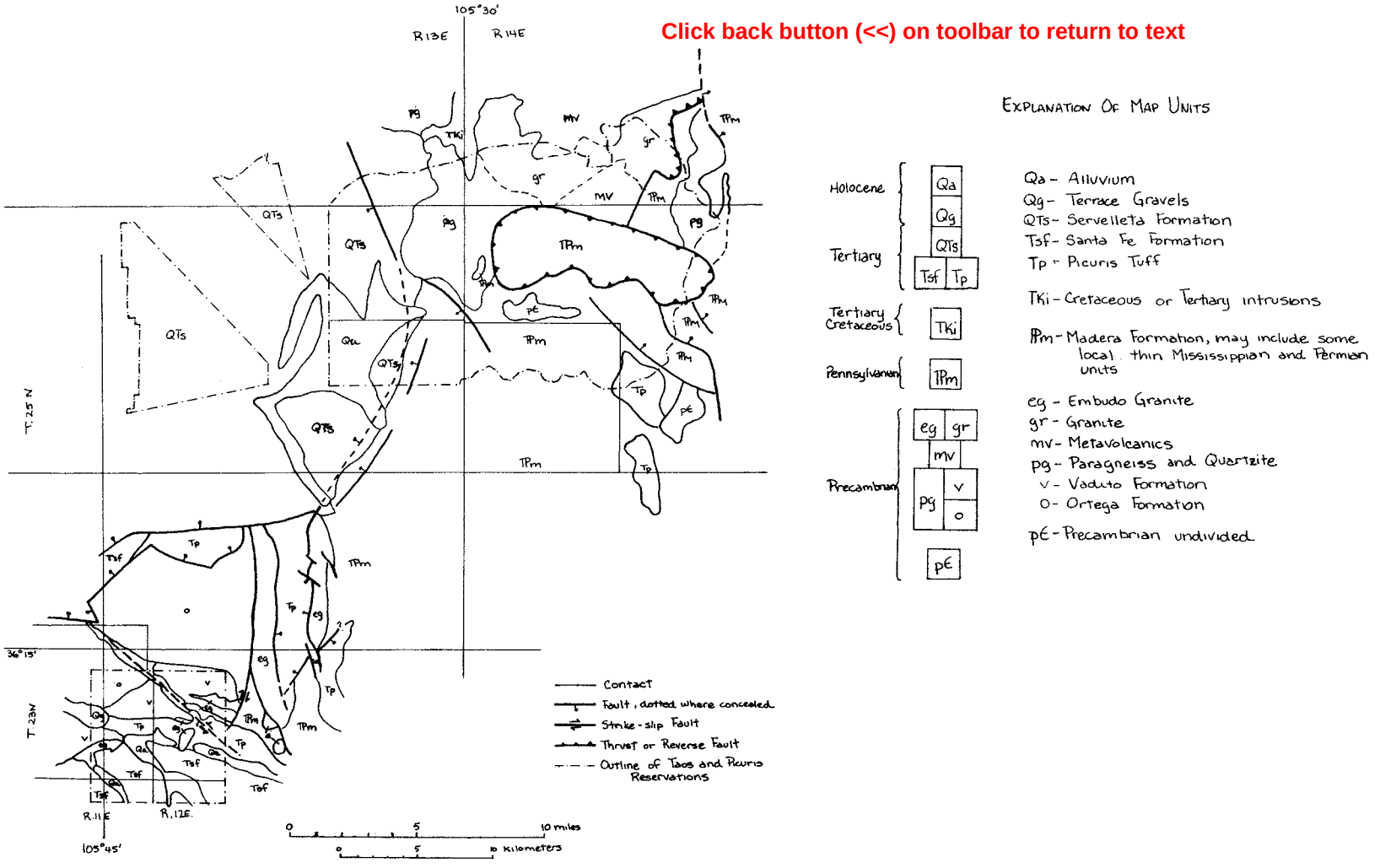

Figure 2. Geologic map of Taos and Picuris Indian Reservations and vicinity.

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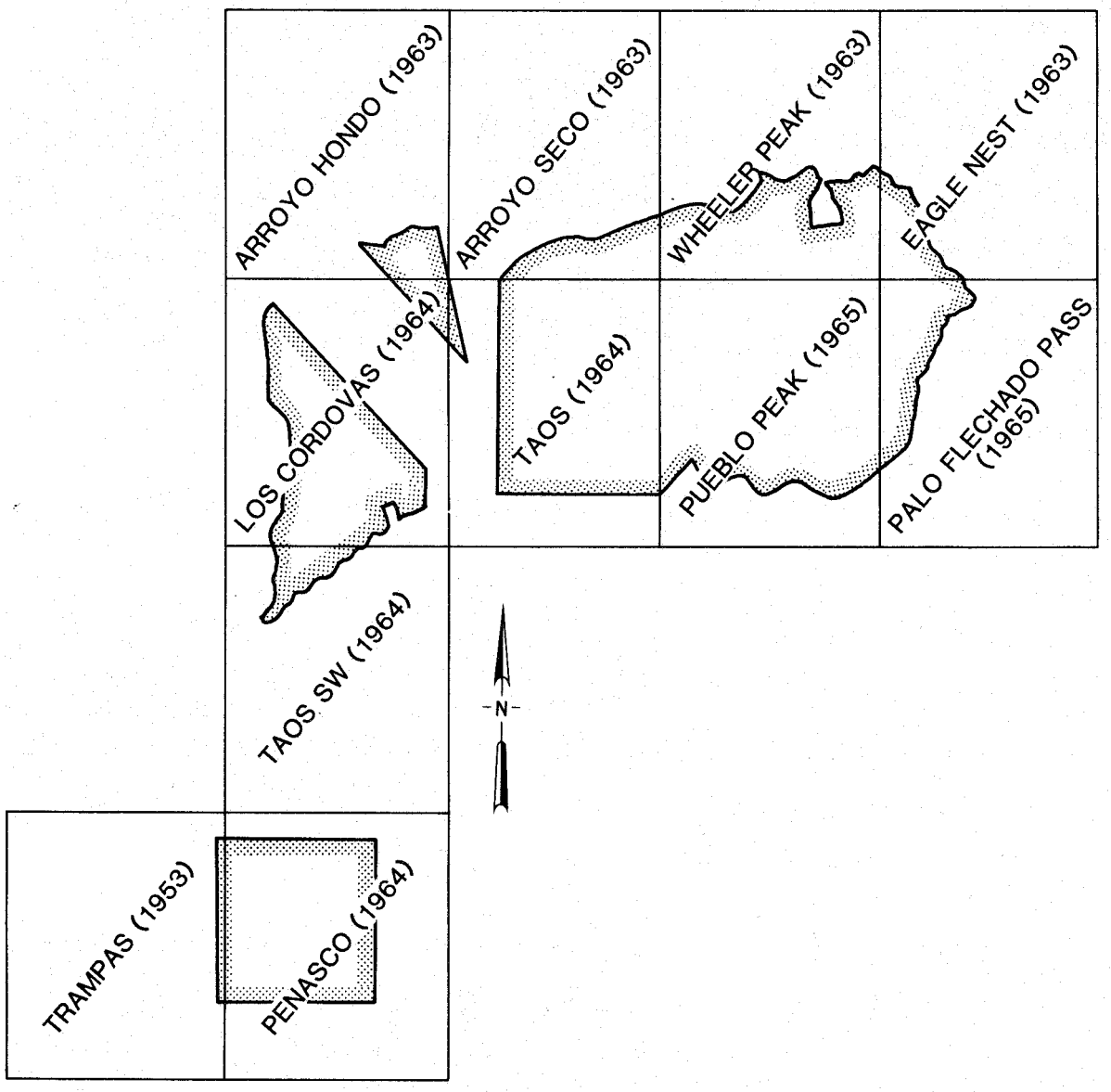

Figure 3. Map showing U.S. Geological Survey topographic map coverage of the Taos and Picuris Indian Reservations, Taos County, New Mexico.